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designed for the photography of the spectrum of the chromosphere ("flash spectrum"), the comparative study of the spectra of center and limb, the measurement of the solar rotation, the determination of the pressure at different levels in the solar atmosphere, and for various other purposes.

The auxiliary apparatus includes a reflecting slit, especially adapted for the photography of the spectra of pores and other minute regions; a device for securing uniform density of the spectra of umbra, penumbra and photosphere in a single exposure; a special guiding device, to maintain any part of the Sun's image on the slit with great accuracy throughout an exposure; a parallel motion apparatus, to facilitate accurate orientation of the instrument; polarizing apparatus, with simple and compound quarter and half-wave plates for various wavelengths; and an electric arc for comparison spectra.

GEORGE E. HALE.

A SUN-SPOT HYPOTHESIS.

The following tentative working hypothesis of sun-spots is proposed merely as a guide to further research. As the result of an eruption, or some other cause tending to produce rapid convection, a gaseous column moves upward from within the Sun toward the surface of the photosphere. Vortex motion is initiated by the difference in rotational velocity of adjoining zones or by irregularities of structure and is maintained by convection. The circulation in the vortex is vertically upward and then outward along the photosphere, as in a terrestrial tornado. Expansion produces cooling at the center of the vortex, and a comparatively dark cloud (the umbra) results. As in HARKER's electric furnace experiments,[1] a rapid flow of negative ions sets in towards the cooler gases at the center from the hotter gases without. The ions, whirled in the vortex, produce a magnetic field.

The descending gases (especially hydrogen) in the higher atmosphere of the Sun are drawn in toward the pole of the magnet along the lines of force, as in BIRKELAND and STÖRMER's theory of the aurora. This accounts for the configuration of the hydrogen ($H\alpha$) flocculi, as shown by the spectroheliograph.

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[1] See *Nature*, July 18, 1912.

Hitherto we have assumed the spot to be single. The typical spot-group originates through the development of a second spot to the east (following) the primary spot, the line joining the two making only a small angle with the equator. The polarities of the two principal spots (smaller companions are usually present) are opposite, and the hydrogen ($H\alpha$) flocculi surrounding a bipolar group resemble the lines of force about a bar magnet. Two alternative hypotheses may be offered to account for these phenomena. According to the first, the lower extremity of the vortex of the primary spot, lagging behind the upper extremity, turns up to meet the photosphere, thus producing a horse-shoe vortex. As in the case of single (unipolar) spots, the hydrogen and other high-level gases flow toward the two members of the group along the lines of force. According to the second view, the two vortices are independent, with nearly radial axes. The necessary criteria of selection can probably be found by a comparative study of the principal members of a bipolar group, special attention being directed to the inclination of the axes of the vortices to the line of sight (as given by the Zeeman effect), the direction of flow (inward or outward) of the vapors at different levels, and the relative temperature and pressure of the two spots.

GEORGE E. HALE.

THREE INTERESTING SPIRAL NEBULÆ.

A number of photographs have been made during the past year with the Crossley reflector of nebulæ hitherto unphotographed, and in the course of this work three nebulæ of rather unusual form have been discovered. Figure I shows the spiral nebula N. G. C. 5921 ($\alpha = 15^h\ 17^m.0$; $\delta = +5° 26'$). It has a nebulous central star, and from this extends on each side a nearly straight line of matter from the ends of which spring two strong spiral branches; there are also a number of fainter spiral whorls. The central oval is about 1′.6 long. The photograph from which the cut was made was taken on June 10, 1912, with an exposure of three hours. It somewhat resembles N. G. C. 1300 ($\alpha = 3^h\ 15^m.2$; $\delta = -19° 46'$), shown in Figure II, which is a drawing made from a negative exposed two hours and ten minutes on September 16, 1912.